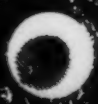
FOREWORD AND OVERVIEW

GREAT LAKES Great Legacy?

The Conservation Foundation

The Institute for Research on Public Policy



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Foreword

Long abused by its human inhabitants, the Great Lakes basin became the focus of an intensive rehabilitative effort by the United States and Canada during the early 1970s. Since then, there have been marked improvements in environmental conditions—Lake Erie is no longer casually referred to as "dead" or "dying"—and the rate of degradation appears to have slowed. But, in many respects, environmental conditions remain unsatisfactory, and the health of the basin's inhabitants remains in jeopardy.

The Great Lakes basin faces complex environmental problems. Many identifiable stresses caused by humans—contamination by chemicals, harvesting of resources, and physical change of the landscape—are not unique to the basin. In that sense, the messages from the Great Lakes should be heeded globally. They serve as a reminder that humans must respect nature's limits and that human well-being and the health of natural ecosystems are intertwined.

The Great Lakes basin has been a laboratory for testing new approaches to protecting and enhancing environmental quality. Because it is the joint responsibility of two nations, the basin provides a model for managing other shared resources around the globe. Environmental problems do not respect national boundaries; those who care about shared resources elsewhere have much to learn from programs tested in the Great Lakes.

In 1987, The Conservation Foundation (CF) and The Institute for Research on Public Policy (IRPP) embarked on a two-year study of the Great Lakes basin to assess environmental conditions and trends

and the adequacy of government programs. CF brought to the project its experience with *State of the Environment* reports. Foundation staff believed that data about environmental conditions in the Great Lakes basin were plentiful but needed to be better organized and made more accessible to decision makers and the public; a single, well-documented volume would promote public understanding of environmental trends and help identify needs for new policies and programs. CF also sought to focus on the Great Lakes because of an abiding interest in promoting greater integration of programs for controlling pollution of land, air, and water. Staff believed that, too often, pollution control programs simply shift risks among air, land, and water, rather than reducing them, and fail to take account of the cumulative effects posed by toxic contaminants in these media.

IRPP staff came to the study with a conviction that there is no necessary conflict between the economy and the environment—that the much-vaunted "trade-off" is a myth and, indeed, that in the long run there can be no successful economic structure built on continuing degradation of the environment and depletion of the renewable resource base. The path-breaking study by the World Commission on Environment and Development, now known as the Brundtland Commission, whose report *Our Common Future* was published in 1987, encapsulated that view in a simple phrase—"sustainable development"—which underlined the extent to which environmental and economic concerns can be mutually supportive. IRPP sought to explore these linkages between economic development and environmental quality in the Great Lakes basin, to identify the need for greater integration of environmental considerations with economic decisions affecting agriculture, energy, and other societal investments. IRPP emphasized the importance of institutional structures to assure widespread involvement and participation in community decisions and action to deal with these issues.

Despite the commitment of both institutions to reporting on environmental conditions, each brought to the project a wariness of environmental statistics. Environmental data are not as abundant or precise as economic data, so it is sometimes difficult to describe the state of the environment as objectively as, say, the economy. Also, there is little point in reproducing data for data's sake; the environmental data that do exist must be analyzed rather than merely reported. Further, the lack of data proving beyond doubt that environmental problems

are caused by particular human actions should not be used as an excuse for inaction.

This report concludes that, although progress has been made in rehabilitating the Great Lakes ecosystem, much more must be done. A new agenda is needed. Future policies for the Great Lakes basin must emphasize anticipation and prevention along with rehabilitation. They must cope with the legacy of deterioration inherited from the past, while ensuring that undesirable environmental legacies are not created for future generations. Anticipatory programs must encompass and reduce the broad range of stresses on the Great Lakes ecosystem. More efficient use of energy, less chemically dependent agriculture, and changes in manufacturing processes to reduce dependence on toxic substances and limit their production are among the measures required. Implementing the new agenda will be a job for more than traditional pollution control and natural resource agencies. Transportation, energy, and agriculture agencies, and many others, must mount a searching reevaluation of their policies to assure that actions taken to satisfy short-term needs do not create long-term environmental problems.

This report was produced by a six-member project team: at CF, Dr. Richard A. Liroff (project director), Dr. Theodora Colborn, and Sharon Green; at IRPP, Alex Davidson (project director), R.A. (Tony) Hodge, and Dr. C. Ian Jackson. The overview for the report was drafted initially by IRPP's Walter Stewart, in consultation with the project team. A companion *Conservation Foundation Letter*, containing additional policy recommendations, was drafted by Rice Odell.

Assistance also was provided by other CF and IRPP staff, a binational advisory panel, consultants, and "friends of the project." The project team consulted more than 200 individuals in both government and the private sector, who generously gave of their time and information in personal interviews and notes, phone conversations, and other contacts. Without their willing help, this project would not have been possible. More detailed acknowledgments accompany the full report.

This experiment in binational cooperation would not have been possible without generous financial support given to The Conservation Foundation and The Institute for Research on Public Policy. It was provided by the Joyce Foundation, the Charles Stewart Mott Foundation, the George Gund Foundation, the Moriah Fund, the Prince Charitable Trust, the Gaylord Donnelley 1983 Gift Trust, the USX

Foundation, the Laidlaw Foundation, Environment Canada, the Ontario Ministry of the Environment, Dofasco, Dow Chemical, Esso Petroleum, Manulife, Noranda Group, Polysar, Shell Canada, Stelco, Suncor, Union Carbide, and donors of unrestricted funds to The Conservation Foundation. All of this support is gratefully acknowledged.

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Overview

An Ecosystem in Trouble

Despite regulatory vigilance to rein in polluters and significant government cleanup efforts over the last two decades, the environment of the Great Lakes basin is still in trouble. Dramatic evidence remains that the Great Lakes are imperiled by continuing habitat destruction and the long-term accumulation of toxic chemicals, which are increasingly pervasive throughout the ecosystem.

Many of the signs of environmental crisis are clearly evident to the 35 million people who reside within the Great Lakes region.

- Around the Great Lakes, 42 particularly degraded localities have been singled out by the International Joint Commission (IJC), as "Areas of Concern." A combination of human wastes, toxic industrial garbage, and relentless ecological destruction has left these areas with environmental crises that can only be relieved by expenditures of vast sums of money and decades of remedial attention.
- Some of the beaches in the Great Lakes region are permanently closed because they are not safe for bathing; many others are closed at periodic intervals because of fecal and chemical contamination.
- The most productive natural systems of the Great Lakes region are wetlands, but two-thirds of them have been filled, drained, or bulldozed out of existence.
- Many of the nearly 80,000 small lakes in the Great Lakes basin, like countless others in southern Canada and the northeastern United States, are dying slowly from the effects of acid rain.

- But acid rain is not the only air-related problem. Clear evidence is now available that large quantities of toxic chemicals find their way into the Great Lakes ecosystem after having been carried perhaps several thousand miles by air currents. Thus, long-range deposition accounts for more than 90 percent of the dangerous polychlorinated biphenyls (PCBs) found in Lake Superior and is the *only* significant source of chemicals such as DDT and toxaphene, which are restricted in the United States and Canada but still used in Mexico and Central America.
- Tests of underground water systems throughout the Great Lakes region indicate steadily mounting contamination from the leaching of chemicals dumped on the land.

The symptoms are evident everywhere, and are reflected in the minutiae of life as well as the grand sweep of nature. The plight of aquatic species, fish-eating birds, and some land animals that spend part or all of their lives in the Great Lakes region is ominous.

- Bald eagles along the shores of the lakes do not reproduce as well as those that reside inland; in some lake areas, bald eagles do not reproduce at all.
- Such problems are not unique to bald eagles; other fish-eating birds and animals at the top of the food web have suffered marked developmental abnormalities that have resulted in significant increases in birth defects and population declines in some species.
- Many species of fish no longer survive in the waters of the lakes, and many of the survivors can no longer reproduce *in situ*.
- New varieties of fish have been introduced to replace the species destroyed by human activities. However, authorities warn that these new species should be eaten only in small quantities because they are contaminated with poisonous chemicals.

Evidence is growing that the well-being of the region's human inhabitants cannot be divorced from the fate of the Great Lakes' wildlife.

- By the process called "biomagnification," which passes along toxic substances in higher and higher levels as they proceed upward through the food web, contaminants that are almost undetectable in lake water may be magnified hundreds of thousands of times within the flesh of a Great Lakes fish. That is why it is often not safe to eat the fish that swim in the same water that one can drink. Humans, too, are constantly accumulating toxic

chemicals that may not be lethal but may be associated with long-term, adverse health, developmental, and reproductive effects.

- The suite of chemicals introduced into the Great Lakes environment over the past half-century has been shown in the laboratory to disrupt normal functioning in cells of animals. The clinical effects of residues on human health are not yet understood. It is known, however, that such chemicals are associated in animals with a number of reproductive, neurological, immunological, and carcinogenic effects and with abnormal sexual development. Stepped-up efforts to test for parallel effects in human beings are a clear priority.

Urgent action is needed by federal, state, provincial, and local governments in both Canada and the United States if the process of long-term environmental degradation in the Great Lakes region is to be reversed. Yet it is increasingly clear that simply augmenting what has been done—greater control of polluters, more resources for cleaning up crisis areas, piecemeal restrictions on physical development—is not going to be a sufficient response.

A far-reaching commitment to reduce the environmental assault on the Great Lakes from all sources is necessary. This will require attention not only to direct discharges of pollution but also to the long-range deposition of toxic chemicals from the air, as well as the indirect contamination caused by "nonpoint" sources such as runoff from agriculture and urban streets. Governments at all levels must develop programs designed to anticipate and prevent environmental problems from occurring in the first place. This will necessitate economic policies that encourage the private sector and government to design production processes and facilities that produce far less waste rather than policies that focus largely on cleaning up waste after it is produced. Local governments throughout the basin must develop new ways of assessing the total environmental impacts of physical development.

The long-term environmental health of the Great Lakes region cannot be secured until the cumulative adverse environmental effects of all human activities are reduced to levels that the total ecosystem—not just the water but the land, the air, and the wildlife as well—can tolerate. There are four reasons why this will be exceedingly difficult to accomplish.

First, huge residual problems from environmental contamination and past destructive development still must be confronted.

Second, greatly increased environmental protection efforts in both Canada and the United States have already succeeded in doing the "easy" things. The next generation of remedial steps will be both more complex and much more expensive.

Third, an action agenda will require unprecedented levels of international cooperation between Canada and the United States. Indeed, it may require a degree of coordinated and integrated response that has proved difficult to achieve even among different layers and agencies of government *within* each country.

Finally, it may be that even the most stringent conventional pollution control measures and restrictions on ecologically destructive development will not be enough. The challenge to restore the health of the Great Lakes ecosystem may require sweeping changes in life-style from societies increasingly dependent on the motor car for transportation, chemicals for agricultural production, fossil fuels for energy, and human-made environments for recreation. The environment must become a mainstream economic issue for both societies. This means that environmental quality must become a principal concern of cabinet members concerned with tax and fiscal policies and of the chief executive officers of major corporations, not just a fixation of those directly charged with environmental protection.

Great Lakes, Great Legacy?, from which these conclusions emerge, is a two-year, binational study of the Great Lakes basin undertaken by The Conservation Foundation in the United States and The Institute for Research on Public Policy in Canada. This report confirms that it is not possible merely to deal with one element in the environment—water, air quality, land, living organisms—and hope thereby to cure the whole. Work in the Great Lakes and elsewhere has shown that it is necessary to treat the elements of the entire ecosystem within a region as interconnected. Moreover, in the open system of the environment, noxious debris wafted into the air hundreds—even thousands—of miles away can become, within days, the source of waterborne contamination in the Great Lakes. Government responses to the environmental stress can succeed only if they thoroughly consider all of these factors.

This study also underscores the need for a dramatic break from the crisis management approach to environmental degradation that persists in the Great Lakes region. Time and again, environmental contamination has been allowed to continue to a point where it threatens human health and wildlife; the cumulative consequences of ill-planned, piece-

meal development are not assessed until their damage is apparent. Today, the challenge is to move beyond the cycle of periodic environmental crises to anticipate and indeed prevent future legacies of environmental destruction.

One positive note is the fact that the institutional wherewithal already exists to integrate environmental quality efforts and eclipse the crisis management mode of environmental protection. A remarkable set of institutions and mechanisms on both sides of the border can support and coordinate the substantial actions that are necessary to reclaim the natural heritage and ecosystem health of the Great Lakes region. These include: the International Joint Commission—established by Canada and the United States in 1909—with its many boards and committees; the Council of Great Lakes Governors; diverse member organizations such as Great Lakes United, as well as many other nongovernmental and governmental institutions; and formal and informal links among scientists, academics, policy makers, other professionals, and concerned citizens. There is no reason to think that a new, single "superagency" to manage the Great Lakes region would, in fact, offer an improved institutional framework.

What is needed to rescue the Great Lakes region from its continuing environmental decline is the will to act and the discipline to take a long-term perspective. It seems clear that this is an area in which public opinion in both countries is well ahead of politicians. Poll after poll in both the United States and Canada has confirmed the importance of the environment in the public mind and the willingness to take action to improve the situation.

Crucial ingredients to such action, however, are still missing. For the course to be reversed, there must be *understanding* of the severity of the environmental perils, *foresight* to anticipate crises before they hit, *political leadership* willing to stand tall for the environment, and an unflagging *public commitment* to provide the financial resources necessary to achieve environmental protection.

A LEGACY OF DESTRUCTION AND CRISIS RESPONSE

The first settlers from Europe found in the Great Lakes region a vast area of rich soil, dense forests, and abundant fish, game, and fresh water. From the outset, the arrival of European civilization set off a pattern of uncontrolled development and assault on the natural environment that has continued largely unabated to this day.

Prosperity was wrung from a countryside increasingly tamed, conformed, and made comfortable. Swamplands turned into cities, forests became farms, lakes became millponds, and rivers became sewers. Transportation corridors slashed across the land, and harbors edged the lakes; industrial complexes were created, and vast areas of wilderness habitat eliminated. Of course, this kind of development process was not unique to the Great Lakes. But "these inland seas," as they were once called, seemed so incalculably huge, and became so central to the expanding nations on both sides of the border, that their visible distress, when at last it began to be noticed, came as a shock.

Late in the last century and early in this one, epidemics of cholera and typhoid swept the Great Lakes region, and hundreds of men, women, and children died. The epidemics were traced to supplies of drinking water that had been contaminated with raw sewage. This was the Great Lakes region's first recognizable, major public health and environmental crisis. Society reacted by chlorinating the water; the epidemics passed. Yet, in the late 1940s and early 1950s, tests showed that the level of harmful bacteria were triple those found earlier in the century.

The 1930s brought a second environmental crisis, one that continued for several decades. This crisis appeared to affect not people but fish. In pioneer days, salmon were caught in all the rivers that empty into Lake Ontario, and many farms were paid for by the salmon catch. At Newcastle, Ontario, salmon were so numerous in the late 18th century that women waded into the water to seine them with flannel petticoats. Sturgeon came up the large rivers every spring to spawn; there were so many that they were considered pests. Lake trout, whitefish, and the freshwater herring, or cisco, were common, along with muskellunge, northern pike, walleye, bass, and dozens of other species.

Fish populations were threatened simultaneously on three fronts: they were victims of new species introduced into the system, they were suffering from the degradation of water quality, and they were being overfished. The parasitic sea lamprey, an eel-like fish, reached Lakes Huron and Michigan when the Welland Canal provided a detour around Niagara Falls, and lake trout disappeared from these lakes soon after. Pollution, which led to the overproduction of algae, robbed lake water of much of its oxygen and devastated the fish population. At the same time, overfishing added to the problem. In Lake Erie alone, the walleye catch ran to an average 7 million pounds a year in the 1940s; it dropped to 328,411 pounds in 1968.

In 1955, in response to increasingly alarmed protests from lake fishermen, the Great Lakes Fishery Commission was created. In a natural experiment without precedent, a variety of innovative management initiatives has since led to a rebounding of the fishery and the creation of a multibillion dollar sport-fishing industry. Again, a crisis apparently was met and conquered.

But the "quality" of fish has not recovered. Several key species, including the lake trout, are no longer naturally self-sustaining and remain only because of expensive artificial stocking programs. New exotic organisms (with an unknown impact on the ecosystem) continue to find their way into the Great Lakes in the bilge water of ships. Advisories warn against high levels of fish consumption because of toxic contamination. Although fish have become readily catchable once again, whether they are fit for human consumption is questionable.

Moreover, by the 1960s, the degradation of Lake Erie was extreme. Nutrient enrichment, mainly phosphorus, had led to excessive eutrophication—that is the abundant growth of plant life, whose decay in turn depletes the water of life-supporting oxygen. Huge algal blooms piled up rotting on beaches. Lakes and rivers near numerous municipal and industrial areas in the region were devoid of visible aquatic life. The Cuyahoga River in Cleveland, Ohio, ran a chocolate brown or rust color and was choked with debris, oils, scum, and floating organic sludges. Even lower forms of life such as leeches were absent. On June 22, 1969, the Cuyahoga was carrying such high concentrations of oil and other flammable industrial wastes that it caught fire and burned two railway bridges beyond use. Some observers pronounced Lake Erie "dead." Perhaps the other Great Lakes were not far behind.

For the third time, society found itself reacting to an environmental crisis in the Great Lakes basin. Although the United States and Canada had commissioned studies of boundary waters' pollution through the IJC in 1912 and again in 1946, and loud warnings had been sounded, little action had resulted. In 1964, a third study was initiated. This time, the result was the Great Lakes Water Quality Agreement of 1972. Controls on phosphorus discharges to the lakes were introduced, and an extensive set of broad studies under the Pollution from Land Use Activities Research Group (PLUARG) was initiated.

Action brought results. Lake Erie and the other Great Lakes have, to varying degrees, visibly and invisibly improved in quality. So, too, have many urban waterfronts, where a burst of development is bringing a revival of economic activity.

Ambient concentrations of phosphorus have been reduced to levels that are allowing the recovery of much of the aquatic ecosystem. To date, more than U.S.$10 billion has been spent to upgrade municipal sewage treatment and to bring the problems of nutrient enrichment and excessive eutrophication under control. This recovery must be considered a significant success story.

However, the battle is far from won. The amounts of phosphorus discharged into the system and "ambient levels"—the total amount of phosphorus present in the system—have been reduced but still have not met target objectives set by the Great Lakes agreement. Oxygen depletion in the deep central basin of Lake Erie remains a concern. More than 30 local areas around the major lakes and many hinterland lakes, particularly on the U.S. side, still experience elevated levels of phosphorus and the associated problems of eutrophication. Furthermore, in the shadows, a second nutrient issue has become a nagging concern. While phosphorus levels have declined, nitrogen levels have grown, and the ratio between the two, an important factor for the balance of natural systems in the lakes, has changed. So far only minor shifts in the nature of the plankton in Lakes Michigan and Ontario have been found, but careful monitoring of long-term consequences is essential.

The fourth crisis registered on the public consciousness was the contamination of Great Lakes waters with persistent toxic chemicals. In the 1970s, the degraded condition of Cleveland's harbor could be seen repeated in many harbors around the Great Lakes. Analyses of bottom sediments tracked massive increases in the discharges of contaminants and clearly identified industrial and municipal sources. The levels of persistent toxic chemicals in the water itself grew alarmingly high. Waterfowl populations, fish, and wildlife dependent on the aquatic ecosystem were found laced with toxic contaminants, deformed, and dying. Was human health in jeopardy?

Again, society reacted. In 1978, a revised Great Lakes Water Quality Agreement was signed. The new document continued controls on phosphorus but shifted the emphasis to the issue of toxic contaminants. Furthermore, driven by the results of the PLUARG studies demonstrating the connection between the status of the lakes and human activities throughout the drainage area, an "ecosystem approach" was agreed on as a governing strategy for management of the Great Lakes basin. This binational recognition of the principle that all components

of the ecosystem must be considered as an interconnected whole (air, land, water, and living organisms) represented a major step in international environmental cooperation.

There was another major advance. The new agreement adopted a philosophy of "zero discharge" of persistent toxic substances and a parallel policy of virtual elimination of such substances en route to zero discharge. In principle at least, there was no longer an "acceptable level" of contamination by these toxic substances. Again, action brought results; the reduction in loadings was mirrored in improved water quality throughout most of the region—until recently.

In the wake of the agreement, the critical movement of contaminants among different media—air, land, surface water, and groundwater—was increasingly recognized. Concern was voiced that regulation of one component of the system without regard for the others, and interactions among them, would inevitably limit success. Direct discharges to water could be controlled, but if, for example, the atmosphere was delivering chemicals from the local incinerator or from fertilizers, herbicides, and pesticides used hundreds and even thousands of miles away, the improvement achieved would be limited. Despite growing appreciation of these linkages, concrete action to address them has not been sufficient.

Beyond water quality, other water issues have also surfaced. Extreme high and low water levels have led to difficulties for many users of the lakes—shoreline residents, shippers and marina owners, and generators of hydroelectric power. High levels combined with storms have resulted in hundreds of millions of dollars in property damage along shorelines. Conversely, low levels have caused financial losses for shippers and energy producers.

Many of those affected by varying lake levels have blamed "nature" for their problems and want to see more human control. Yet human ability to manage lake levels is limited. It cannot, for example, eliminate the problems that stem from putting buildings in the wrong places along shorelines. In the case of high water levels, most of the difficulties have been a result of construction in vulnerable areas. In the case of low levels, builders' expectations have been dashed as natural variations in conditions occur and as lake-front properties have become beached hundreds of feet from the water. In both cases, it has been the lack of recognition and unwillingness to adapt to natural conditions on the part of human society that has caused the problem, not "nature."

THE CUMULATION OF INSUFFICIENT RESPONSES

The pattern is clear. Since European settlers arrived in the Great Lakes region, development and economic expansion have pushed ahead with woefully inadequate consideration of the natural environment. As an environmental crisis has occurred that threatens human life or interferes with immediate human wants, a partial, bandage solution that alleviates concern is found and applied. Some success is achieved. The cycle is frequently repeated. As the problems become more complex, the actions that society takes with its narrow, reactive perspective become progressively less adequate. Hidden costs are simply passed on.

In fact, when a major breakthrough in protection of the environment occurred, it did not come as a result of anything as dramatic as an epidemic but in a rather dull, bureaucratic way. During the first few years of this century, a series of disagreements between Canada and the United States led to the Boundary Waters Treaty of 1909 and the subsequent establishment of the International Joint Commission, which was given the authority to deal with any matters affecting the use or diversion of boundary waters. A small clause slipped into the treaty committed each nation not to pollute the waters of the other. It is that clause that has led to the creation of one of the most innovative and successful mechanisms in the world for the binational resolution of environmental issues. The instrument is there. Unfortunately, it has not always been in use.

Moreover, as the 20th century has proceeded, humankind's capacity to alter and even destroy the environment has accelerated. This has placed a greater burden on fledgling efforts to protect the environment. One of the world's great industrial areas emerged in the Great Lakes basin, and a population of several million people scattered throughout the region became 35 million residents heavily clustered in large metropolitan areas. With this growth has come an equally dramatic shift in society's economic base, from subsistence resource extraction to the development of a scientific industrial complex. As part of this evolution, there has been an extraordinary increase, particularly in the four decades since the end of World War II, in the use of manufactured chemicals. Every facet of life has been touched; the increase in chemical use has been accompanied by a massive dumping into the environment of the by-products and leftovers of the process.

It has been 40 years since the dramatic growth in chemical use began, 25 years since scientists first recognized the crisis of toxic

contaminants in the fish and wildlife of the Great Lakes, 20 years since the Cuyahoga River burst into flames, and a decade since the Great Lakes Water Quality Agreement was amended to focus on the issue of toxic contaminants. Environmental indicators point to the conclusion that the sum of all the crisis responses that have accumulated during this timespan is not sufficient to protect the Great lakes ecosystem from further deterioration, much less to restore it to a healthier condition in the long run. A review of the state of the Great Lakes environment shows that, despite all the gains made in recent years, the ecosystem is still, on balance, threatened.

THE STATE OF THE GREAT LAKES ENVIRONMENT

What is the state of the environment in the Great Lakes basin today? Figure 1 lists 15 factors and summarizes the data presented in this study. In addition to presenting an overview of the current status and trend for each factor, the figure indicates a "response time" and a "spatial context." The response time provides a rough estimate of time during which the factor would "recover" should human-induced stresses be eliminated. The spatial context provides an indication of the geographic area in which the factor operates.

Notwithstanding the overview presented in figure 1, the actual status of the Great Lakes ecosystem is difficult to summarize because of the complex knowledge required about the interaction between all environmental factors. The Great Lakes aquatic system alone includes, in addition to transboundary waters of the Great Lakes and their connecting channels, over 80,000 inland lakes with a combined area greater than that of Lake Erie. The system also contains nearly half a million miles (750,000 kilometers) of inland streams and rivers, a groundwater system that provides drinking water for 7.5 million basin residents and serves to transmit contaminants both to those drinking-water supplies and to surface water, and the St. Lawrence River, which provides the final link to the ocean.

A SEAMLESS WEB OF ENVIRONMENTAL PROBLEMS

Although a general recovery of Great Lakes water quality from pollution by toxic metals and organic contaminants has been under way since the 1970s, there are lingering problems with some extremely dangerous substances such as dioxins and furans. Furthermore, the

Figure 1
Indicators of Ecosystem Health in the Great Lakes Basin

A. Contaminants in the Environment

Element	*Recovery Time*	*Spatial Context*	*Status*
1. Air quality	days to months	local to global	Air quality probably has improved over the last two decades because of declines in emissions of various pollutants. Quality still is unsatisfactory in many areas, principally because of high levels of ozone. The problem of airborne toxic pollutants is not yet well defined or addressed. Atmospheric deposition remains a problem for water quality, aquatic organisms, and vegetation. More reductions in emissions are needed.
2. Surface water quality	months to years	basin	Substantial progress on excess nutrient problems has been made in the last two decades, by resolving crisis situations in Lakes Erie and Ontario, although trophic conditions still are not at targeted levels in some areas. Eutrophication and acidification remain serious problems in many inland lakes within the basin. Concentrations of nitrogen compounds have been rising at least over the last two decades in the Great Lakes, and their implications are not yet clear. Nonpoint pollution (urban and rural) remains a serious problem. Cumulative concentrations of metals in three Great Lakes are at elevated levels. Forty-two degraded Areas of Concern require a massive remedial effort. Although concentrations of some pollutants meet ambient water quality standards, concentrations are still high enough to cause serious contamination problems in fish and other wildlife.

3. Contaminated sediments	decades	basin, river, and lake bottoms	Sediments contaminated with metals and organic compounds are a serious problem in 41 of 42 Areas of Concern. In many locations, sediments remain a continuing source of contaminants and excess nutrients for the food web. Concentrations of many contaminants in recent sediments are significantly less than in older sediments, with some exceptions.
4. Groundwater	decades to centuries	basin	Water sources are contaminated in various locations throughout the region. Degraded conditions stemming from persistent toxic substances will last long into the future. Groundwater can be a major source of contaminants to surface water. Preventive activities are in their infancy, so groundwater quality is degenerating.
B. Fish and Wildlife			
5. Body burdens of toxics	years to decades (generational effects)	local to continental	Contaminant levels in many organisms are substantially lower than they were in the early 1970s, but declines appear to have leveled off and present trends are difficult to interpret. For many substances, levels remain above objectives specified in the Water Quality Agreement or other guidelines and standards. Continued high levels for substances whose use has been restricted signals releases of contaminants previously deposited in the ecosystem, continued release from improper storage of remaining stocks, and remaining uses in remote areas.
6. Population status	years to decades	local to continental	Populations of many bird species are recovering. Problems remain for specific species or populations in particular locations. Some key species, such as lake trout, still are unable to establish self-sustaining populations in several lakes. Biota are threatened in acidifying inland lakes.
7. Habitat	days to centuries	basin	The pace of habitat destruction is substantially reduced from earlier eras, but protection of remaining habitat is still a concern. A coordinated basinwide effort is needed.

8. Fisheries	years to decades	local to basin	A substantial reduction in the lamprey population during the past 20 years and heavy stocking of exotic salmonids and other species has permitted development of a robust sport fishery. The forage base for the fishery may be limited due to controls on phosphorus discharges. The artificially managed "fish ranch" in the lakes may be quite fragile, and the future of the commercial fishery still is uncertain.
C. Terrestrial Conditions			
9. Forests	decades	local to basin	Many forests are maturing after recovering from massive overcutting and fires during the late 19th and early 20th century. The future increasingly is seen in managing public lands to allow for multiple uses of forest resources. Forests are at risk from transported air pollutants, such as ozone and acid deposition, with a prospect of widespread stress in the coming decades from climate change.
10. Wetlands	years to decades	local	Two-thirds of the original wetlands in the basin have been destroyed since the beginning of European settlement. The key role of wetlands in the Great Lakes ecosystem is now recognized. Public policies encouraging wetland destruction must be adjusted to make them consistent with wetland protection goals.
11. Soil erosion	years to decades	local to basin	Available data indicate that erosion generally is below the threshold of concern for short-term, on-site productivity, but there is growing evidence of serious impacts on water quality due to transport of nutrients and pesticides from agricultural areas.
12. Agricultural productivity	years to decades	local to basin	Yields of major crops have risen dramatically through use of fertilizers, pesticides, new varieties of crops, and other changes in farming practice. Economic and environmental doubts about long-term sustainability of chemically dependent agriculture are prompting growing interest in alternative farming practices.

13. Shorelines	days to years	basin	Record high levels of the Great Lakes in the mid-1980s increased demand by riparian landowners for protection. There is continued public reluctance to accept that substantial year-to-year changes in levels are beyond cost-effective human control. Long-term declines are envisaged due to global warming. Greater emphasis is needed on shoreline management to prevent development in vulnerable areas, protect habitat, and allow multiple use.
D. Human Conditions			
14. Human health	days to years	local to global	Available public health data on birth defects and cancer incidence are inadequate as indicators of health effects that may arise from biomagnification and bioaccumulation of toxic substances in the Great Lakes food web. Subgroups at risk may be offspring of those who consume sizable amounts of fish and other predators. A special effort is needed to develop measures for and examine the incidence of subtle developmental problems in groups at risk. Other probable risks to human health occur in areas of contaminated air and groundwater.
15. Economic conditions	months to years	local to global	The Great Lakes basin is the manufacturing heartland of the United States and Canada. The U.S. side was affected strongly by the recession of the early 1980s. A general recovery is under way, speeding the transition from manufacturing dominance towards a more service-oriented economy. Facility modernization has benefited the environment.

swift progress in reducing toxic contaminants that took place in the late 1970s and early 1980s appears to have slowed or stopped.

Recently deposited bottom sediments in the Great Lakes proper are significantly less contaminated than those deposited in previous decades. But progress on this front is mitigated by the legacy of the past, when virtually every form of chemical, mineral, and organic waste known was deposited in the depths of the lakes. Inevitably, most of these buried contaminants are recirculated into the water, both by natural processes and when the removal of contaminated sediments is required—during dredging, for example, or for the construction of new facilities. This source of potentially dangerous contamination will be around for decades.

And there is much more than water to think about. Not too long ago the air of many urban centers was visibly degraded with smoke. As usual, society reacted long after creating the problem: regulations were passed to control the levels of particulate matter in the air. Yet unhealthy levels of air pollution continue. Although the political wrangling over acid rain has popularized concern about air, the larger issue of long-range transport of all airborne contaminants, which includes the precursors of acid rain as well as ozone and a range of conventional and toxic contaminants, has not received the attention it deserves. The presence of toxic contaminants carried by the air to humans and wildlife, to growing crops, and to water is worrisome. Hexachlorobenzene, for example, a pollutant resulting from incomplete combustion and the manufacture of chlorine-containing chemicals, is subsequently transferred to land, water, and living organisms. Anglers are warned by health departments about eating large lake trout caught in Lake Superior; the fish are contaminated by PCBs deposited into the lake from the atmosphere. When it comes to assessing the ecological health of the Great Lakes basin, government environmental protection programs have frequently underemphasized the relationship between air pollution and water quality.

Over the past two decades, both the emissions and ambient levels of sulfur dioxide—a major contributor to acid rain—have been significantly reduced. But acid rain continues to be a serious problem. One reason is that virtually no progress has been made in reducing emissions of nitrogen oxides, another of its precursors. Indeed, Ontario's emissions of nitrogen oxides were 29 percent higher in 1984 than in 1970. Some versions of proposed revisions of the Clean Air Act could permit U.S. utilities to emit up to one million additional

tons of nitrogen oxides into the atmosphere annually by the year 2000. In addition, the transborder movement of ozone, carried from major urban areas of the midwestern United States, looms as a growing problem for Canada—recent studies show that about 50 percent of Ontario's ozone originates in the United States!

On land, new regulations and increased public scrutiny have helped to reduce many of the worst "point" sources of contaminants—factories, waste treatment plants, hazardous waste dumps. At the same time, however, nonpoint pollution, such as runoff from urban streets and agricultural areas, remains substantially unaddressed. And groundwater contaminated by existing land-based hazardous waste sites is now likely the single largest source of contaminants to the Niagara River—and may be for many decades.

Direct discharges from human activities, resuspension of contaminants from bottom sediments, contaminant discharge through groundwater, and atmospheric deposition are all contributing to a maintenance of contaminant concentrations in the Great Lakes food web at levels that threaten the health of fish, wildlife, and humans. Because of the natural processes of bioaccumulation and biomagnification, contaminant levels in predators at or near the top of the food web are of particular concern. In some places, these fish, birds, and mammals exhibit severe problems.

Within the human population, health risks are elevated for those living in areas with polluted air and contaminated groundwater. Even more important, there may be subtle effects on human health that have gone largely undetected and that stem from contaminants in the food web. Certain identifiable subgroups of the population appear to be at elevated risk of exposure. These include human embryos, infants, and children whose parents have bioaccumulated substantial quantities of toxic chemicals that exist in fish and waterfowl. The health effects in the offspring may include altered cognitive, motor, and behavioral development. Preliminary studies suggest that these subtle effects may be far more significant among at-risk populations than cancer and gross physical defects. The need for "more data" is urgent.

Discussion of pollution tends to overshadow vast physical changes that have occurred in the basin. Only a third of the original wetland area now exists. Little old-growth forest is left in developed areas. Transportation corridors have reduced the continuity of wilderness areas. All of this has drastically altered wildlife habitat, reducing natural productivity and the diversity of species.

The pressures on the Great Lakes ecosystem from humans' physical restructuring of the environment continue. Destruction of wetlands and vital habitat probably occurs at a slower rate than it did in years past, but protecting the important areas that are left remains an uphill battle.

THE COSTS OF SEVERE ENVIRONMENTAL DEGRADATION

Forty-two Areas of Concern (areas where conditions are particularly degraded) have been identified by the International Joint Commission's Great Lakes Water Quality Board since 1973. These include major municipal and industrial centers on rivers, harbors, and connecting channels. Although many of the sites continue to exhibit problems of bacterial pollution, eutrophication, and habitat loss, the dominant concern at all but one today is toxic substance contamination.

In 1985, the eight Great Lakes states and the province of Ontario committed themselves to developing Remedial Action Plans (RAPs) for each Area of Concern, aimed at restoring beneficial uses and encouraging the reestablishment of environmental health and integrity. Preliminary cost estimates are now available for 8 of the 42 RAPS. Based on these early estimates, it is apparent that tens of billions of dollars from both private and public sources will be required for implementation.

As high as these early estimates seem, they reflect only part of the legacy from past action left to the current generation. Neither the plans nor the estimates address conditions throughout the basin, nor do they fully account for the difficult technical issues of:

- contaminated bottom sediments;
- cleanup or containment of contaminants at all the hazardous and solid waste management and industrial and municipal facilities in the basin (including protection and cleanup of groundwater sources);
- further reductions of contaminant emissions and discharges to achieve zero discharge of persistent toxic contaminants; and
- rehabilitation of critical fish and wildlife habitat such as wetlands.

Nor do the cost estimates adequately cover:

- the replacement and maintenance of municipal water and sewage handling and treatment infrastructure that will be required to meet

rising environmental standards, to prevent sewer overflows, to replace aging facilities, and to provide for population growth;
- rehabilitation and maintenance of degraded areas currently not included on the list of 42 Areas of Concern; and
- accidental spills, discharges, and other catastrophes, whether natural or induced by humans.

A comprehensive estimate including all of the above costs is not available. Nevertheless, it is obvious that these costs are enormous. To restore environmental integrity to the Great Lakes basin and maintain the ecosystem in a healthy state will require substantially more than the tens of billions of dollars already identified as necessary to meet immediate problems in the Areas of Concern.

These large costs should be seen in perspective. Not all of the problems can be dealt with overnight, in a year or two, or even in 10 years. The costs will be spread over a long period. The gross annual product of the Great Lakes region exceeds U.S.$1 trillion. Nevertheless, the costs of remedying past wrongs will likely become a much larger factor in the regional economy than they are today, particularly if no investments are made now to prevent the creation of new legacies.

That is the crisis ahead. Already the resources needed to reestablish environmental integrity in the Great Lakes basin may exceed the price that one generation is willing to bear. But a commitment must be made to ensure that the legacy of environmental costs to be left to the future is less than what has been left by the past.

The RAP process offers some insight into how this might be achieved. It is a community-based approach to designing the best possible solution to the particular problems facing each site. It operates on a scale that can foster understanding of the true nature of the issues and the linkage between economic and environmental well-being. Because of the large eventual costs of implementing RAPs and the inevitable trade-offs that must be made, full participation of the community is essential if creative, effective, and equitable solutions are to be found. Though the RAP process has only just begun, and government support has been uneven, a remarkable start has been made. The process represents a revolutionary new approach to environmental decision making for both the United States and Canada. Complex technical and social issues are being dealt with collectively at a grass-roots level. The way is being prepared for the kind of resource commitment that will be required in the future.

SEVEN PRINCIPLES FOR ACTION

In recent decades, the United States and Canada have made serious and costly attempts to slow the rate of environmental deterioration in the Great Lakes basin. They have spent, collectively, more than U.S.$10 billion building and improving municipal sewage treatment plants in response to the alarm bells that began ringing some decades ago, and have thus avoided turning the Great Lakes into a vast pool of human waste. Major programs have been set in motion to remove and dispose of hazardous wastes. Billions of dollars are still needed to support the RAP process described above.

The overwhelming conclusion of *Great Lakes, Great Legacy?*, however, is that neither country is spending enough, or doing enough, to check the insidious long-term decline of the Great Lakes ecosystem.

On the remedial front, it is painfully clear that only the easiest problems have been tackled and the cheapest remedies, such as curbing the dumping of sewage and toxic chemicals straight into the system, applied. Most of the more difficult challenges lie ahead—such tasks as controlling airborne toxic substances, protecting and restoring groundwater quality, dealing with the problems of toxic metals and pervasive, persistent organic chemicals.

Moreover, the relentless onslaughts of increased population, expanded economic activity, and the resulting higher levels of resource consumption place ever greater strains on the region's natural resource systems and threaten to overwhelm progress in reducing per capita waste and consumption. The dangers of adding new legacies of environmental decay and ecosystem destruction on top of ones that society has yet to remedy are significant.

To resolve the environmental problems of the past and prevent the advent of new crises in the future will require enormous resolve not only on the part of governments but by private citizens and corporations. Seven major principles should guide decision making.*

1. **The environment and the economy must be put on an equal footing, to be weighed and measured together as the basis for development decisions.**

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*These are presented in different form in chapter 10 of this report. More detailed recommendations for federal, state, and local officials in the United States are presented in *The Conservation Foundation Letter*, 1989, no. 5, available from The Conservation Foundation.

The environment must be a fundamental concern in the mainstream of policy making, not tacked onto the end of the process. Today, the evaluation of economic well-being is divorced from the evaluation of environmental quality, and the former almost always outweighs the latter. The public is now saying that the environment and the economy can be mutually supporting. But, for this to happen, the two must be fully integrated in decision making.

Government programs often pay subsidies to aid economic development—draining wetlands, for example. Such subsidies may promote environmental damage that other government programs attempt to correct. The real long-term costs, including the environmental costs, of all the subsidies, tax breaks, and incentives that promote development should be accounted for at the outset, before projects are approved. Water supply systems, sewage treatment, waste management, and energy supply should be priced to reflect environmental costs and benefits. If such steps are not taken, it is likely that the Great Lakes environment will deteriorate further as the 21st century approaches. But the application of policies to ensure that public services are priced to include all costs would not only reduce environmental damage, it would relieve a great deal of economic pressure placed on financially strapped local governments.

2. The operating perspective of governments, industry, and the public must be extended to include the entire ecosystem: water, land, air, and all living organisms.

The oversimplified focus on single aspects of the ecosystem, often at the expense of the ecosystem as a whole, must be expanded to include the broad ecosystem. Pollution control programs that simply shift the risks from air to land to water must be replaced by programs that recognize these cross-media connections. A total ecosystem approach must highlight the importance of other objectives for achieving environmental quality: cutting per capita energy, water use, and generation of waste; recycling; reducing auto emissions and toxic pesticide use; and increasing tree cover and wildlife habitat.

As part of this expanded perspective, a special effort will be required to develop systems of monitoring necessary for establishing the indicators of chemical, physical, and biological sustainability needed to go hand in hand with well-developed measures of economic activity. The implications to the health of the ecosystem of physical disruption, contaminant movement, nutrient cycling, and energy flows are all at

primitive stages of understanding and require attention. It is only through such a broad systemic approach that a comprehensive assessment of the overall economic/environmental health and sustainability of the region will be possible.

3. **Canada and the United States must develop an Ecosystem Charter for the Great Lakes Region to supplement the Great Lakes Water Quality Agreement with a much broader-based arrangement. This charter should recognize the intimate relationships among environmental health, human well-being, and economic activity. A good beginning to this process would be the early adoption of a bilateral accord on transboundary air pollution and the adjustment of the terms of reference of the IJC to go beyond the current focus on water quality.**

The ecosystem charter should set demanding goals for reductions in chemical, physical, and biological stresses on the environment. One such goal would be zero discharge of all contaminants. Another goal would be commitment to a policy of no net losses of wetlands in future development and restoration, where possible, of devastated areas. A third would be to protect natural shorelines from development and to protect special areas of natural beauty, wildlife habitat, or ecological significance. Other goals would include the restoration of bald eagle communities throughout the basin and the restoration of a naturally sustaining fishery. Finally, this charter should recognize the rights and needs of future generations.

4. **Commitments made over the past 15 years must be fulfilled. Governments must set goals, put in place a clear tracking system to monitor progress, and follow through on implementation.**

The goal of zero discharge of persistent toxic substances was set in the U.S. Clean Water Act of 1972 and confirmed for the Great Lakes basin in the Water Quality Agreement of 1978. It is time for these aging commitments to be met, time for governments to follow through on the RAPs with more money and fewer words, time for real muscle to be put behind lakewide toxic management plans, watershed management plans, and shorezone management commitments. Time, in short, for the U.S. and Canadian governments to begin to enforce their laws effectively.

The International Joint Commission has made substantial progress

in developing a cooperative program for the two nations. Yet government support—as distinguished from government rhetoric—often has been fainthearted at best, derisive at worst. The U.S. and Canadian governments have tended to marginalize the IJC and not to take advantage of its strength as a cooperative, problem-solving mechanism. In addition, the IJC itself has tended to bow easily to this marginalization and has not pursued its mandate with anything like the vigor and persistence it requires. Much more international cooperation could be facilitated if both sides redoubled their commitment to the IJC.

5. Governments must act now to increase monitoring and research to promote the understanding of human and ecosystem health conditions in the Great Lakes basin.

One major conclusion of this project is that, on both sides of the border, monitoring and surveillance to provide critical feedback on environmental quality are grossly inadequate.

A call for more monitoring and research is not an argument to delay action until more is known—clear signals that the ecosystem is unhealthy provide reasonable cause for concern about human health. Rather, it is an argument for supporting long-overdue studies of the links between environmental and human health and ensuring that the findings of these studies are brought to the public's attention.

The human health focus must be expanded beyond concern for such obvious diseases as cancer to subtle, chronic conditions and intergenerational effects. Major tasks include research on human groups at heightened risk of exposure to chemicals, studies of the mechanisms by which toxic substances affect humans and wildlife, enhanced monitoring of wildlife populations, and improved warnings about Great Lakes fish and wildlife to further discourage their consumption by females planning to have children.

6. In allocating resources available for environmental protection, priority generally should go to prevention first and restoration second.

The legacy from the past includes an environmental bill for tens of billions of dollars; that legacy has also made clear that it is far cheaper to prevent devastation than to correct it.

The billions society plans to spend on restoration indicate the high value placed on environmental health. But, in the face of demands for large expenditures, priorities will have to be set. Everything cannot

be done now or quickly. It is clearly cheaper to prevent the dumping of contaminants in the first place than to attempt to clean them up once they are widespread in the environment. It is cheaper to protect the remaining wetlands and natural shorelines than to pay the high costs of restoring them once lost.

Of course, restoration plans must be pursued vigorously. But it would be folly to spend billions on restoration while neglecting to spend millions on prevention.

7. A broadly based process of decision making, involving as many people and interest groups as possible, must be utilized and encouraged as a vital part of the ecosystem process.

It is essential to get the best technical solutions, to promote the most equitable trade-offs in the wrenching processes that lie ahead, and to ensure needed public support for the allocation of the massive resources that will be required. The cooperative approach that is the basis of the IJC, the RAPs (with the involvement of those who have a stake in them), and the lakewide toxic management plans all provide a sound basis to get this process off the ground.

RECONNECTING: A VISION OF THE FUTURE

To tackle the legacy of the past and the challenges of the 21st century—to restore the health of the Great Lakes ecosystem and to gird it to meet future ecological stresses—will require far-reaching efforts. If the battle is to be won, Canadians and Americans must join together to anticipate rather than react to emerging environmental conditions.

The last time there was a truly historical battle of the Great Lakes, on September 10, 1813, Captain Oliver Hazard Perry—quite rudely, Canadians have always thought—destroyed an entire flotilla of British vessels on Put-In Bay, near Amherstburg, Ontario. The next battle of the Great Lakes will be less dramatic but more momentous, slower, and vastly more costly, but at least this time the United States and Canada are on the same side. The complications of environmental stresses never before encountered—such as global warming due to increased build-up of greenhouse gases in the environment—could greatly complicate strategic efforts to address already known problems.

Both nations—politicians, business leaders, nongovernmental organizations, and others—must work together to develop a vision of a high quality of life in the Great Lakes region. All of these interests

must decide where they want to go if they are to begin to get there and, to that end, must build the vision of a life-style that recognizes the intimate relationship between human well-being, a healthy environment, and a prosperous economy. The stakes are much too high to continue dealing with the Great Lakes by waiting for a series of crisis-forced reactions.

Today, actions must work with and adapt to natural processes rather than recklessly try to manipulate and control those processes. If the history of the Great Lakes region teaches anything, it is that nature cannot be bludgeoned into submission. Policies must promote development that is compatible with nature. This will mean, for example, adapting shoreline-use policies to the reality of the natural fluctuations of lake levels and ending subsidies and other incentives to build homes now where water will rule tomorrow. It will also mean deemphasizing fish ranching, an artificially supported sport fishery, in favor of the longer-term goal of restoring the natural sustainability of the lakes to the point where native fish species can thrive and be consumed by humans and wildlife alike.

In the final analysis, it is not institutions that are lacking in the efforts to rescue the Great Lakes basin from environmental degradation. Public and private institutions that already exist can and must be harnessed to a new political will. Above all, institutions and political leaders and the public must develop the foresight to cease looking primarily at the present at the expense of the future. It is then, and only then, that humans will be reconnected with the web that is life and will know that their legacy is an enhanced world for their children.

> Whatever befalls the earth, befalls the sons of the earth. Man did not weave the web of life; he is merely a strand in it. Whatever he does to the web, he does to himself.
>
> —Chief Seattle

GREAT LAKES
Great Legacy?

From the Overview

Despite regulatory vigilance to rein in polluters and significant government cleanup efforts over the last two decades, the environment of the Great Lakes basin is still in trouble. Dramatic evidence remains that the Great Lakes are imperiled by continuing habitat destruction and the long-term accumulation of toxic chemicals, which are increasingly pervasive throughout the ecosystem.

Urgent action is needed by federal, state, provincial, and local governments in both Canada and the United States if the process of long-term environmental degradation in the Great Lakes is to be reversed. Yet it is increasingly clear that simply augmenting what has been done — greater control of polluters, more resources for cleaning up crisis areas, piecemeal restrictions on physical development — is not going to be a sufficient response.

A far-reaching commitment to reduce the environmental assault on the Great Lakes from all sources is necessary.

The Conservation Foundation

The Institute for Research on Public Policy